

## LAKE UNION FISH HISTOPATHOLOGY STUDY

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## INTRODUCTION

The links between biological abnormalities and contaminant exposure in fish has been studied intensively in marine waters of Puget Sound (Malins *et al.*, 1982). However, these possible links have rarely been studied in freshwater environments of Washington State. Landolt and Kocan (1987) reviewed studies of contaminants in other freshwater regions in the United States where pathological conditions have been found in fish. In areas of high aromatic hydrocarbon contamination, Bauman *et al.* (1982) found hepatic neoplasms in brown bullheads (*Ictalurus nebulosus*) in Ohio's Black River. Black (1983) induced hepatocellular and oral carcinomas in brown bullheads by painting fish with sediment collected from the Buffalo River in New York, which contained high concentrations of aromatic hydrocarbons.

Gasworks Park, a 20 acre park on the north shore of Lake Union, Seattle, Washington, is the site of a retired coal gasification plant that ran for 50 years ending in 1956. The sediments adjacent to Gasworks Park are heavily contaminated with a number of toxic compounds including polycyclic aromatic hydrocarbons (PAH), heavy metals, and cyanide (Hileman *et al.*, 1985; Yake *et al.*, 1985). Fish residing in this urban lake may be exposed to relatively high concentrations of PAH and heavy metals. To determine if fish exposed to these contaminants show abnormalities, liver, kidney and gills from 157 fish were examined with histopathology methods. Blood was also examined.

## METHODS

### Specimen Collection

A total of 188 fish were collected from Lake Union over two sampling periods. Seventy-three (73) fish were sampled during the first period (June 10-11, 1990); one hundred fifteen (115) were sampled during the second period (September 10-11, 1990). Figure 1 shows the study site. Table 1 reviews species composition by site. Scientific names of fishes are presented in Appendix 1. Fish were caught in June with two fyke nets, one at Gasworks Park and one at Navy Cove. In September the fyke nets were supplemented with a shocking boat operating in the evening at Gasworks Park, Nancy Cove and Portage Bay. All fish were captured live, placed in live tanks or buckets on board the sampling boat, then transferred to shore live in buckets for examination.

### Examination

#### External

A blood sample was obtained from each fish using either caudal vein puncture or severance of the caudal peduncle (depending upon size of the specimen). The fish was then sacrificed by a blow to the head, taxonomically identified, assigned an accession number, measured (total length in mm), weighed (grams), and examined for the presence of externally visible lesions. Mean lengths and weights are summarized in Tables 2 and 3. External lesions are listed in Appendix 2.

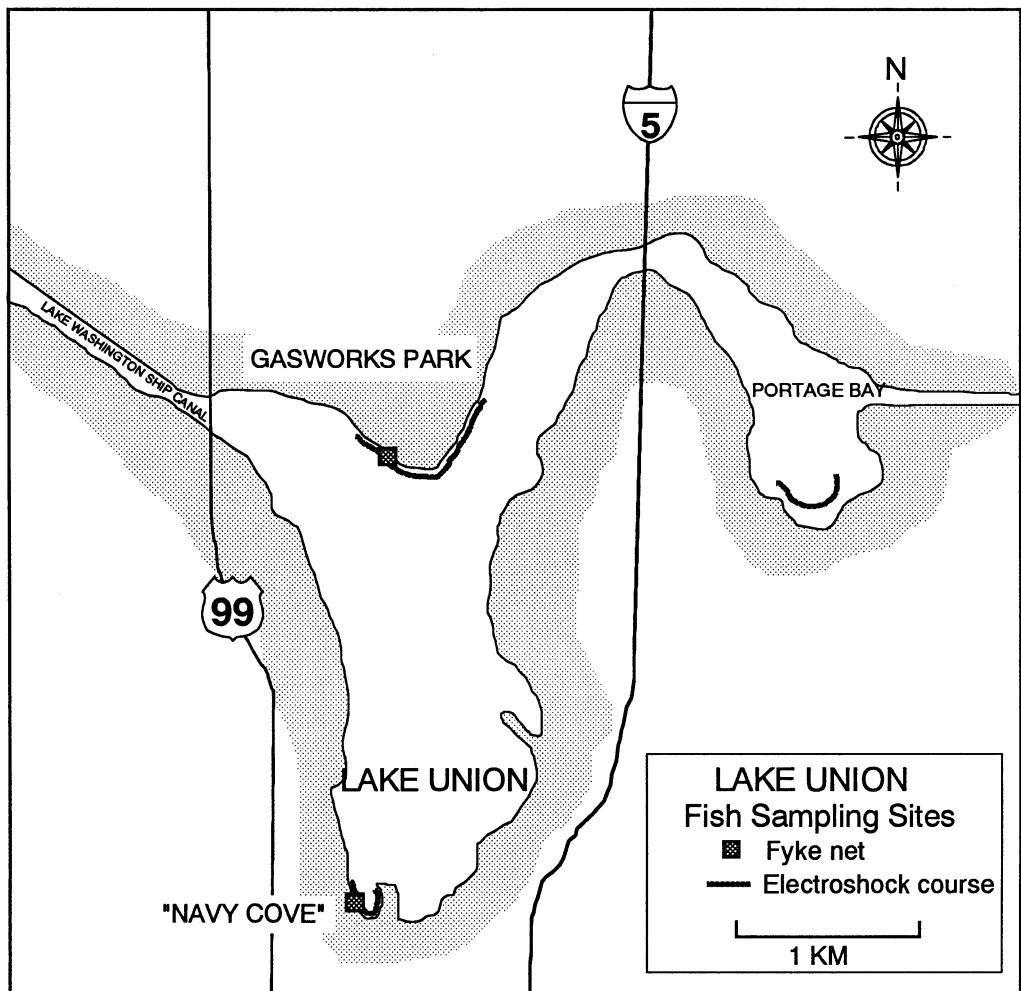


Figure 1. Study site showing location of fish collection

Table 1. Species taken from each collection site during two sampling periods.

| <b>First Collection Period (June 10-11, 1990)</b> |                      |                  |                    |
|---|----------------------|------------------|--------------------|
| <b>Species</b>                                    | <b>Gasworks Park</b> | <b>Navy Cove</b> | <b>Portage Bay</b> |
| Yellow Perch                                      | 6                    | 7                | 0                  |
| Three Spine Stickleback                           | 33                   | 15               | 0                  |
| Pumpkinseed                                       | 1                    | 5                | 0                  |
| Sculpin   | 1                    | 5                | 0                  |
| Squawfish   | 0                    | 0                | 0                  |
| Large Scale Sucker                                | 0                    | 0                | 0                  |
| Largemouth Bass                                   | 0                    | 0                | 0                  |
| Smallmouth Bass                                   | 0                    | 0                | 0                  |
| White Crappie                                     | 0                    | 0                | 0                  |
| Rainbow Trout                                     | 0                    | 0                | 0                  |
| Peamouth Chub                                     | 0                    | 0                | 0                  |
| Bluegill Sunfish                                  | 0                    | 0                | 0                  |
| Brown Bullhead                                    | 0                    | 0                | 0                  |
| Starry Flounder                                   | 0                    | 0                | 0                  |

| <b>Second Collection Period (September 10-11, 1990)</b> |                      |                  |                    |
|---|----------------------|------------------|--------------------|
| <b>Species</b>  | <b>Gasworks Park</b> | <b>Navy Cove</b> | <b>Portage Bay</b> |
| Yellow Perch  | 38                   | 10               | 4                  |
| Three Spine Stickleback                                 | 0                    | 0                | 0                  |
| Pumpkinseed   | 20                   | 4                | 4                  |
| Sculpin   | 3                    | 0                | 0                  |
| Squawfish   | 1                    | 3                | 0                  |
| Large Scale Sucker                                      | 3                    | 0                | 1                  |
| Largemouth Bass   | 5                    | 0                | 2                  |
| Smallmouth Bass   | 2                    | 0                | 0                  |
| White Crappie   | 2                    | 0                | 1                  |
| Rainbow Trout   | 5                    | 0                | 0                  |
| Peamouth Chub   | 2                    | 0                | 0                  |
| Bluegill Sunfish  | 2                    | 0                | 0                  |
| Brown Bullhead  | 2                    | 0                | 0                  |
| Starry Flounder   | 1                    | 0                | 0                  |

Table 2. Mean length (mm) of fish taken from each collection site during two sampling periods.

| First Collection Period (June 10-11, 1990) |               |           |             |
|--|---------------|-----------|-------------|
| Species                                    | Gasworks Park | Navy Cove | Portage Bay |
| Yellow Perch                               | 188.2         | 227.3     | --*         |
| Three Spine Stickleback                    | 75.8          | 69.9      | --          |
| Pumpkinseed                                | 137.0         | 88.6      | --          |
| Sculpin                                    | 137.0         | 119.4     | --          |
| Squawfish                                  | --            | --        | --          |
| Large Scale Sucker                         | --            | --        | --          |
| Largemouth Bass                            | --            | --        | --          |
| Smallmouth Bass                            | --            | --        | --          |
| White Crappie                              | --            | --        | --          |
| Rainbow Trout                              | --            | --        | --          |
| Peamouth Chub                              | --            | --        | --          |
| Bluegill Sunfish                           | --            | --        | --          |
| Brown Bullhead                             | --            | --        | --          |
| Starry Flounder                            | --            | --        | --          |

| Second Collection Period (September 10-11, 1990) |               |           |             |
|--|---------------|-----------|-------------|
| Species  | Gasworks Park | Navy Cove | Portage Bay |
| Yellow Perch                                     | 164.2         | 167.9     | 162.0       |
| Three Spine Stickleback                          | --            | --        | --          |
| Pumpkinseed                                      | 130.5         | 122.2     | 129.0       |
| Sculpin  | 108.7         | --        | --          |
| Squawfish  | 216.0         | 225.3     | --          |
| Large Scale Sucker                               | 264.0         | --        | 364.0       |
| Largemouth Bass                                  | 192.2         | --        | 101.0       |
| Smallmouth Bass                                  | 216.0         | --        | --          |
| White Crappie                                    | 164.5         | --        | 170.0       |
| Rainbow Trout                                    | 253.2         | --        | --          |
| Peamouth Chub                                    | 225.0         | --        | --          |
| Bluegill Sunfish                                 | 105.5         | --        | --          |
| Brown Bullhead                                   | 286.0         | --        | --          |
| Starry Flounder                                  | 149.0         | --        | --          |

\* -- indicates that no fish were collected

Table 3. Mean weight (g) of fish taken from each collection site during two sampling periods.

| First Collection Period (June 10-11, 1990) |               |           |             |
|--|---------------|-----------|-------------|
| Species                                    | Gasworks Park | Navy Cove | Portage Bay |
| Yellow Perch                               | 84.2          | 167.8     | --*         |
| Three Spine Stickleback                    | 5.6           | 4.5       | --          |
| Pumpkinseed                                | 62.5          | 19.7      | --          |
| Sculpin                                    | 30.6          | 21.8      | --          |
| Squawfish                                  | --            | --        | --          |
| Large Scale Sucker                         | --            | --        | --          |
| Largemouth Bass                            | --            | --        | --          |
| Smallmouth Bass                            | --            | --        | --          |
| White Crappie                              | --            | --        | --          |
| Rainbow Trout                              | --            | --        | --          |
| Peamouth Chub                              | --            | --        | --          |
| Bluegill Sunfish                           | --            | --        | --          |
| Brown Bullhead                             | --            | --        | --          |
| Starry Flounder                            | --            | --        | --          |

| Second Collection Period (September 10-11, 1990) |               |           |             |
|--|---------------|-----------|-------------|
| Species  | Gasworks Park | Navy Cove | Portage Bay |
| Yellow Perch                                     | 59.1          | 63.9      | 46.2        |
| Three Spine Stickleback                          | --            | --        | --          |
| Pumpkinseed                                      | 53.2          | 42.7      | 47.0        |
| Sculpin  | 11.7          | --        | --          |
| Squawfish  | 79.0          | 103.3     | --          |
| Large Scale Sucker                               | 200.0         | --        | 560.0       |
| Largemouth Bass                                  | 127.4         | --        | 9.5         |
| Smallmouth Bass                                  | 167.5         | --        | --          |
| White Crappie                                    | 62.0          | --        | 72.0        |
| Rainbow Trout                                    | 130.4         | --        | --          |
| Peamouth Chub                                    | 98.0          | --        | --          |
| Bluegill Sunfish                                 | 24.5          | --        | --          |
| Brown Bullhead                                   | 310.5         | --        | --          |
| Starry Flounder                                  | 35.0          | --        | --          |

\* -- indicates that no fish were collected

## Internal

The body cavity was opened and the internal organs were inspected for the presence of visible defects. Representative tissue samples were collected from each of the following organs: liver, kidney, gill. Tissues were preserved in Bouin's fixative.

## Histopathology

Preserved tissues from 157 fish were prepared for light microscopy. Tissues were dehydrated through a graded ethanol series, cleared with xylene, embedded in paraffin, sectioned at 5 um and stained with hematoxylin and eosin dyes. Stained sections of liver, kidney, and gill tissue were examined by Busch. Each organ was first scanned at low magnification (40X) for general form and contour. Subsequently, the entire section was examined at high magnification (430X) for the presence of pathological alterations. A verbal description of each lesion was recorded on the data sheet and the severity of the change was indicated by a numerical score ranging from mild (severity score = 1), to moderate (severity score = 2), to severe (severity score = 3). Because the terminology used in verbal descriptions frequently varies from one pathologist to another, a numerical code was assigned to each lesion. The codes were derived from the National Ocean Data Center's (NODC) histopathology coding system, and were displayed on the datasheet as hyphenated numbers containing two descriptors. The first number indicated the suborgan, the second number indicated the specific lesion. For example, code 12-116 indicates that helminth parasites (116) were present on the serosa (12) of the liver. The histopathological data are compiled in Appendix 2. Histopathological terms may be found in Appendix 3.

## Hematology

Blood films were prepared, air dried, preserved with methanol and stained with Giemsa dye. Blood smears were evaluated by Busch. A review of hematological terms may be found in Appendix 3. NODC codes are not available for hematological terms; thus, they were not used in the data summary (Appendix 2).

## Gonad

Gonadal tissue was examined in order to identify the sex of the fish. The tissue was not evaluated for the presence of lesions.

## RESULTS

All examination results are reviewed in Appendix 2.

## Liver

The majority of the lesions noted were conditions that could be attributed to parasitism (e.g. free parasites, encapsulated parasites, parasitic granulomas, parasitic serositis) or conditions that represent non-specific response to injury (e.g. necrosis, mononuclear cell infiltrates). No

neoplasms or signs of severe toxicity were noted. Two possible preneoplasms were observed. An area of focal change similar to an eosinophilic nodule was found in a yellow perch collected near Gasworks Park; an area of focal change similar to a clear cell focus was found in a yellow perch collected in Navy Cove.

Nuclear pleomorphism and non-uniform vacuolation, changes frequently associated with chronic exposure to contaminants, were prominent in sculpins. It is possible that this species is uniquely sensitive to contaminant exposure or that some feature of their life style increases their exposure.

#### Kidney

Few lesions were noted in the kidney. The most common lesions were changes associated with parasitism (e.g. free parasites, parasitic granulomas). Other changes included focal inflammation, deposition of pigment in glomerular tissue, and vacuolation of tubular epithelium. No neoplasms, preneoplasms, or signs of profound toxicity were observed.

#### Gills

With the exception of the presence of parasites on the surface of the lamellae, relatively few lesions were noted in the gill tissue. Microaneurysms and epithelial cell hyperplasia were observed with some frequency. These conditions may result from a variety of infectious and non-infectious disease processes.

#### Blood

Serious hematological changes were not observed. Most of the alterations noted (e.g. bacteremia, activated macrophages, leucocytosis, leucopenia) are changes that may accompany bacterial infection. There was no evidence of neoplastic disorder or severe dyscrasias.

### CONCLUSIONS AND RECOMMENDATIONS

This study represented the first attempt by the Department of Ecology to evaluate the health of fish in Lake Union. As a consequence, this project was more a feasibility study than a systematic survey. Goals of the project were to compare the utility of different types of sampling gear, to determine the species of fish that might reasonably be obtained, and to examine the health of as many species as possible in order to identify target species candidates.

If further work is to be conducted in Lake Union, the following recommendations are made.

1. Focus collection efforts on sculpins and brown bullheads. Sculpins, because of their biological characteristics, their tendency to be non-migratory, and the lesions observed in the present study, appear to be a good target species. If it is possible to target two species, bullheads would be a good second choice due to their benthic habitat and histopathological responses observed during studies of this species in other areas with the same classes of pollutants present.

2. Focus collection efforts on obtaining adequate (60 fish per site) numbers of one or two target species, rather than low numbers of many species.
3. Identify a reference site and compare the prevalence of lesions at that site with the prevalence at various stations within Lake Union.
4. In the absence of grossly visible lesions in other organs, collect only liver tissue for histopathological evaluation.

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## **APPENDICES**

Appendix 1. Scientific names of fish caught in histopathology study.

| Common Name             | Latin name                       |
|-------------------------|----------------------------------|
| Yellow perch            | <i>Perca flavescens</i>          |
| Three spine stickleback | <i>Gasterosteus aculeatus</i>    |
| Pumpkinseed             | <i>Lepomis gibbosus</i>          |
| Sculpin                 | <i>Cottus sp.</i>                |
| Squawfish               | <i>Ptychocheilus oregonensis</i> |
| Largescale sucker       | <i>Catosomus macrocheilus</i>    |
| Largemouth bass         | <i>Micropterus salmoides</i>     |
| Smallmouth bass         | <i>Micropterus dolomieu</i>      |
| White crappie           | <i>Pomoxis annularis</i>         |
| Rainbow trout           | <i>Salmo gairdneri</i>           |
| Peamouth chub           | <i>Mylocheilus caurinus</i>      |
| Bluegill sunfish        | <i>Lepomis macrochirus</i>       |
| Brown bullhead          | <i>Ictalurus nebulosus</i>       |
| Starry flounder         | <i>Platichthys stellatus</i>     |

Appendix 2. Catalog of all fish collected and examined.

| NO.   | STATION  | SPECIES     | LIVER*           | SEV. | KIDNEY | SEV.       | CODE | GILL               | SEV.             | CODE                  | BLOOD                |
|-------|----------|-------------|------------------|------|--------|------------|------|--------------------|------------------|-----------------------|----------------------|
| LU-8  | Gasworks | Stickleback | Focal Necrosis   | 1    | 14-308 | Sporozoa   | 2    | 351-58             | Trichodinids     | 1                     | 314-34 Rosette-Rbc   |
|       |          |             | Granulomas       | 2    | 73-219 |            |      | Interlam. Parasite |                  | 1                     | 314-185 Regen Anemia |
|       |          |             | Vacuolation      | 3    | 14-482 |            | 0-01 | NVL                |                  |                       |                      |
| LU-9  | Gasworks | Stickleback | NVL              | ?    | ?      | Sporozoa   | 2    | 351-58             | NVL              | 0-01                  | NVL                  |
| LU-10 | Gasworks | Stickleback | Multiloc. Struc. | ?    | 14-308 |            | 0-01 | NVL                |                  |                       |                      |
| LU-11 | Gasworks | Stickleback | Focal Necrosis   | 2    | 14-529 |            |      |                    |                  |                       |                      |
| LU-12 | Gasworks | Stickleback | Mitotic Figures  | 1    | 14-529 |            |      |                    |                  |                       |                      |
| LU-13 | Gasworks | Stickleback | Non Uni Vacuo    | 2    | 14-483 | Sporozoa   | 1    | 351-58             | Aneurysms        | 1                     | 314-907 NVL          |
|       |          |             | Non Uni Vacuo    | 3    | 14-483 |            | 0-01 |                    | Monogenetic Trem | 1                     | 314-100 Vac Macro    |
|       |          |             | Nuclear Pleo     | 2    | 14-406 |            |      |                    |                  | 1                     | Bacteremia           |
|       |          |             | Focal Necrosis   | 2    | 14-308 |            | 0-01 | NVL                |                  | 1                     | Karyol-Wbc           |
| LU-14 | Gasworks | Stickleback | NVL              |      |        |            | 0-01 | Monogenetic Trem   |                  | 1                     | Bacteremia           |
| LU-15 | Gasworks | Stickleback | NVL              |      |        |            | 0-01 | NVL                |                  | 1                     | Aniso-Rbc            |
| LU-16 | Gasworks | Stickleback | NVL              |      |        |            | 0-01 | Glomer Pig         | 1                | 301-363 NVL           | 0-01 NVL             |
| LU-17 | Gasworks | Stickleback | Focal Necrosis   | 2    | 14-308 | NVL        | 0-01 | Glomer Pig         | 1                | 301-363 Trichodinids  | 2 314-34 NVL         |
| LU-18 | Gasworks | Stickleback | Coccidia         | 3    | 14-58  |            | 0-01 | NVL                |                  | 1                     | Lame Hyperplasia     |
|       |          |             | Non Uni Vacuo    | 2    | 14-483 | NVL        | 0-01 | NVL                |                  | 1                     | 314-707              |
|       |          |             | Nuc Pleo         | 2    | 14-406 |            | 0-01 | NVL                |                  | 1                     | 314-34 Aniso-Rbc     |
| LU-19 | Gasworks | Stickleback | Focal Necrosis   | 1    | 14-308 | Sporozoa   | 2    | 351-58             | Trichodinids     | 1                     | 314-34 NVL           |
|       |          |             | Necrosis         | 2    | 14-308 | Glomer Pig | 1    | 301-363            |                  | 1                     | 314-34 NVL           |
| LU-20 | Gasworks | Stickleback | NVL              |      |        |            | 0-01 | NVL                | 0-01 Aneurysms   | 1                     | 314-907 Leucopenia   |
| LU-21 | Gasworks | Stickleback | NVL              |      |        |            | 0-01 | NVL                | 0-01 Aneurysms   | 1                     | 314-907 Leucopenia   |
| LU-22 | Gasworks | Stickleback | Mononuc Infil    | 1    | 14-234 | Sporozoa   | 1    | 351-58             | NVL              | 0-01                  | Leucopenia           |
| LU-23 | Gasworks | Stickleback | Focal Necrosis   | 2    | 14-308 | NVL        | 0-01 | NVL                | 0-01             | 0-01                  | Bacteremia           |
| LU-24 | Gasworks | Stickleback | Coccidia         | 3    | 14-58  | NVL        | 0-01 | Aneurysm           | 1                | 314-907 Leucopenia    |                      |
| LU-25 | Gasworks | Stickleback | Focal Necrosis   | 3    | 14-308 | NVL        | 0-01 | NVL                | 0-01             | 0-01                  | Reticulocytes        |
| LU-26 | Gasworks | Stickleback | Focal Necrosis   | 2    | 14-308 | NVL        | 0-01 | Aneurysms          | 1                | 314-907 Lobed Rbc Nuc |                      |
| LU-27 | Gasworks | Stickleback | Coccidia         | 1    | 14-58  | NVL        | 0-01 | NVL                | 0-01 NVL         | 1                     | 314-907 NVL          |
| LU-28 | Gasworks | Stickleback | Nuc Pleo         | 2    | 14-406 |            | 0-01 | Glomer Pig         | 1                | 301-363 Aneurysms     | 0-01 NVL             |
| LU-29 | Gasworks | Stickleback | NVL              |      |        |            | 0-01 | NVL                | 0-01 NVL         | 0-01 NVL              |                      |
| LU-30 | Gasworks | Stickleback | Multioc Gran     | 2    | 73-219 | NVL        | 0-01 | NVL                | 0-01 NVL         | 0-01 NVL              |                      |
| LU-31 | Gasworks | Stickleback | NVL              |      |        |            | 0-01 | Sporozoa           | 1                | 351-58 Trichodinids   | 0-01 NVL             |
| LU-32 | Gasworks | Stickleback | Vacuolation      | 3    | 14-482 | Nephritis? | ?    | 73-200             |                  | 1                     | 314-34 Aniso-Rbc     |
| LU-33 | Gasworks | Stickleback | NVL              |      |        |            | 0-01 | NVL                | 0-01 Aneurysms   | 1                     | 314-907 NVL          |
| LU-34 | Gasworks | Stickleback | Coccidia         | 2    | 14-58  | NVL        | 0-01 | NVL                | 0-01 NVL         | 2 314-34              |                      |
| LU-35 | Gasworks | Stickleback | Nuc Pleo         | 2    | 14-406 | NVL        | 0-01 | Aneurysms          | 0-01 NVL         | 1 314-907 Aniso-Rbc   |                      |

\* See Appendix 3 for histopathology terms and codes.

**Appendix 2 (con't). Catalog of all fish collected and examined.**

| NO.   | STATION  | SPECIES      | LIVER*   | SEV.                     | CODE*                                      | KIDNEY                | SEV.  | CODE          | GILL                  | SEV.  | CODE             | BLOOD                                  |             |
|-------|----------|--------------|--|--------------------------|--|-----------------------|---|---------------|-----------------------|---|------------------|--|-------------|
| LU-36 | Gasworks | Stickleback  | Coccidia<br>Intersti Inflam<br>Ser Helminth<br>Focal Necrosis<br>NVL | 3<br>1<br>1<br>2<br>0-01 | 14-58<br>14-200<br>12-111<br>14-308<br>NVL |                       |   |               | 0-01                  | Aneurysms                                     | 1                | 314-907 Aniso-Rbc<br>Leucopenia        |             |
| LU-37 | Gasworks | Stickleback  | NVL  | 2                        | 14-308                                     | 0-01                  | NVL   |               | 0-01                  | NVL   | 0-01             | NVL                                    |             |
| LU-38 | Gasworks | Stickleback  | Granuloma<br>Par/Ser Helmin<br>Focal Necrosis<br>Coccidia            | 1                        | 73-219<br>14-111<br>14-308<br>14-58        | Melan Gran<br>NVL     | 1   | 73-219<br>NVL | 0-01                  | NVL   | 0-01             | NVL                                    |             |
| LU-39 | Gasworks | Stickleback  |  | 2                        | NVL  |                       |   |               | 0-01                  | NVL   | 0-01             | Seg Nuc-Rbc<br>Bacteremia<br>Vac Macro |             |
| LU-40 | Gasworks | Stickleback  | NVL  |                          |  | 0-01                  | NVL   |               | 0-01                  | Aneurysms                                     | 1                | 314-907 Bacteremia<br>Aniso-Rbc        |             |
| LU-5  | Gasworks | Yellow Perch | Mononuc Infil<br>Basophilic Body                                     | 1                        | 14-234<br>14-127                           | NVL                   |   |               | 0-01                  | Trichodinids                                  | 1                | 314-34 Leukocytosis                    |             |
| LU-6  | Gasworks | Yellow Perch | Mononuc Infil  | 1                        | 14-234                                     | NVL                   |   |               | 0-01                  | Aneurysms                                     | 3                | 314-907 NVL                            |             |
| LU-63 | Gasworks | Yellow Perch | NVL  |                          |  | 0-01                  | NVL   |               | 0-01                  | Trichodinids                                  | 1                | 314-707 Lam. Hyperplasia               |             |
| LU-64 | Gasworks | Yellow Perch | NVL  |                          |  | 0-01                  | Vacuol Tub Epi<br>Mel Castis Lumen<br>Bowman Dilated<br>Vac Tub Epi | 3             | 20-482<br>3<br>3<br>3 | Trichodinids<br>Monogenetic Trem<br>Aneurysms | 2<br>2<br>1      | 314-34 Lobul Nuc-Rbc<br>314-34 NVL     |             |
| LU-65 | Gasworks | Yellow Perch | Focal Necrosis<br>Mononuc Infil                                      | 1                        | 14-308<br>14-234                           | Vac Tub Epi<br>NVL    | 1   | 20-482        | NVL                   | 0-01  | Monogenetic Trem | 1                                      | 314-100 NVL |
| LU-80 | Gasworks | Yellow Perch | Vacuolation  | 3                        | 14-482                                     | NVL                   |   |               |                       | 0-01  | Protozoan        | 1                                      | 314-74 NVL  |
| LU-81 | Gasworks | Yellow Perch | Vacuolation  | 3                        | 14-482                                     | NVL                   |   |               | 0-01                  | Focal Inflam                                  | 1                | 314-200 NVL                            |             |
| LU-83 | Gasworks | Yellow Perch | NVL  | 3                        | 0-01                                       | NVL                   |   |               | 0-01                  | Trichodinids                                  | 1                | 314-34 NVL                             |             |
| LU-84 | Gasworks | Yellow Perch | Vacuolation<br>Non Uni Vacuol<br>Eosino Focus?                       | 3<br>2<br>?              | 14-482<br>14-483<br>14-703?                | NVL                   |   |               | 0-01                  | Monogenetic Trem                              | 1                | 314-100 NVL                            |             |
| LU-88 | Gasworks | Yellow Perch | Ser Granuloma<br>Mononuc Infil<br>Vacuolation                        | 1<br>1<br>3              | 12-219<br>14-234<br>14-482                 | NVL                   |   |               | 0-01                  | NVL   | 0-01             | Reticulocytes<br>Leukocytosis          |             |
| LU-94 | Gasworks | Yellow Perch | Fibrosis<br>Vacuo<br>Non Uni Vacuol                                  | 2<br>3<br>2              | 14-234<br>14-261<br>14-483                 | NVL                   |   |               | 0-01                  | Aneurysms                                     | 1                | 314-907 Notch Nuc-Rbc<br>Aniso-Rbc     |             |
| LU-95 | Gasworks | Yellow Perch | Vacuolation<br>Focal Inflam<br>Mononuc Infil                         | 3<br>1<br>1              | 14-482<br>14-200<br>14-234                 | Tub Epi Inflam<br>NVL | 1   | 20-200        | NVL                   | 0-01  | NVL              | 0-01                                   | NVL         |
| LU-96 | Gasworks | Yellow Perch |  | 1                        |  |                       |   |               | 0-01                  | Aneurysms                                     | 1                | 314-907 Reticulocytes                  |             |

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**Appendix 2 (con't). Catalog of all fish collected and examined.**

| NO.    | STATION  | SPECIES      | LIVER*                            | SEV.   | CODE*   | KIDNEY           | SEV.   | CODE             | GILL             | SEV.        | CODE                | BLOOD                |
|--------|----------|--------------|-----------------------------------|--------|---------|------------------|--------|------------------|------------------|-------------|---------------------|----------------------|
| LU-97  | Gasworks | Yellow Perch | Non Uni Vacuol<br>Basophil Focus? | 2      | 14-483  | ?                | 14-127 | 2                | 20-482           | Aneurysms   | 1                   | 314-907 Leukocytosis |
| LU-102 | Gasworks | Yellow Perch | Vacuolation                       | 3      | 14-482  | Vac Tub Epi      | 1      | 20-200           | Trichodinids     | 1           | 314-34              |                      |
| LU-104 | Gasworks | Yellow Perch | Vacuolation                       | 3      | 14-482  | Tub Epi Inflam   | 1      | 73-200           | Focal Inflam     | 1           | 314-200 No Sample   |                      |
| LU-108 | Gasworks | Yellow Perch | Vacuolation                       | 3      | 14-482  | Vac Tub Epi      | 1      | 20-482           | Aneurysms        | 1           | 314-907 NVL         |                      |
| LU-109 | Gasworks | Yellow Perch | Vacuolation                       | 1      | 14-234  | NVL              |        |                  |                  |             |                     |                      |
| LU-115 | Gasworks | Yellow Perch | Mononuc Infil<br>Congestion       | 2      | 126-950 |                  |        |                  |                  |             |                     |                      |
| LU-116 | Gasworks | Yellow Perch | Vacuolation                       | 2      | 14-482  | NVL              | 0-01   | Focal Hyperpla   | 1                | 314-707 NVL |                     |                      |
| LU-135 | Gasworks | Yellow Perch | Mononuc Infil                     | 1      | 14-234  |                  |        |                  |                  |             |                     |                      |
| LU-136 | Gasworks | Yellow Perch | Vacuolation                       | 2      | 14-482  | Focal Tub Inflam | 1      | 20-200           | NVL              | 0-01        | NVL                 |                      |
| LU-137 | Gasworks | Yellow Perch | Non Uni Vacuol<br>Basophil Focus? | 1      | 14-234  |                  |        |                  |                  |             |                     |                      |
| LU-138 | Gasworks | Yellow Perch | Vacuolation                       | 3      | 14-482  | NVL              | 0-01   | Monogenetic Trem | 1                | 314-100 NVL |                     |                      |
| LU-139 | Gasworks | Yellow Perch | Vacuolation                       | 3      | 14-482  | NVL              | 0-01   | Trichodinids     | 1                | 314-34 NVL  |                     |                      |
| LU-118 | Gasworks | Yellow Perch | Mononuc Infil                     | 1      | 14-234  |                  |        |                  |                  |             |                     |                      |
| LU-140 | Gasworks | Yellow Perch | Vacuolation                       | 1      | 14-483  | Ductular Inflam  | 1      | 0-01             | Monogenetic Trem | 1           | 314-34 NVL          |                      |
| LU-141 | Gasworks | Yellow Perch | Non Uni Vacuol<br>Focal Necrosis  | 1      | 14-308  |                  |        |                  |                  |             |                     |                      |
| LU-142 | Gasworks | Yellow Perch | Vacuolation                       | 3      | 14-482  | Tub Vac Epi      | 1      | 20-482           | Focal Inflam     | 1           | 314-200 NVL         |                      |
| LU-143 | Gasworks | Yellow Perch | Mononuc Infil                     | 1      | 14-234  | NVL              | 0-01   | Aneurysms        | 1                | 314-907 NVL |                     |                      |
| LU-144 | Gasworks | Yellow Perch | Vacuolation                       | 3      | 14-482  | Focal Inflam     | 1      | 73-200           | NVL              | 0-01        | NVL                 |                      |
| LU-145 | Gasworks | Yellow Perch | Non Uni Vacuol<br>Mononuc Infil   | 2      | 14-234  | Eo Dep Glom      | 1      | 0-0              | Trichodinids     | 2           | 314-34 Pyknotic Rbc |                      |
| LU-146 | Gasworks | Yellow Perch | Vacuolation                       | 3      | 14-482  | NVL              | 2      | 0-01             | Monogenetic Trem | 1           | 314-100 Aniso Retic |                      |
| LU-147 | Gasworks | Yellow Perch | Non Uni Vacuol                    | 1      | 14-483  |                  |        |                  |                  |             |                     |                      |
| LU-148 | Gasworks | Yellow Perch | Vacuolation                       | 3      | 14-482  | NVL              | 0-01   | NVL              | 1                | 314-907 NVL |                     |                      |
| LU-149 | Gasworks | Yellow Perch | Non Uni Vacuol<br>Mononuc Infil   | 2      | 14-483  | NVL              | 0-01   | Focal Inflam     | 1                | 314-200 NVL |                     |                      |
|        |          |              | 1                                 | 14-234 |         |                  |        |                  |                  |             | 0-01 NVL            |                      |

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**Appendix 2 (con't). Catalog of all fish collected and examined.**

| NO.    | STATION  | SPECIES      | LIVER*           | SEV. | CODE*   | KIDNEY                         | SEV. | CODE | GILL | SEV. | CODE                | BLOOD                             |
|--------|----------|--------------|------------------|------|---------|--------------------------------|------|------|------|------|---------------------|-----------------------------------|
| LU-150 | Gasworks | Yellow Perch | Baso Cells Mmc   | ?    | 103-127 |                                |      |      |      | 0-01 | Protozoa            | 1 314-74 Notch Nuc-Rbc            |
| LU-151 | Gasworks | Yellow Perch | Vacuolation      | 3    | 14-482  | NVL                            |      |      |      | 0-01 | Trichodinids        | 1 314-34 NVL                      |
| LU-152 | Gasworks | Yellow Perch | Vacuolation      | 2    | 14-482  | NVL                            |      |      |      | 0-01 | Focal Inflam        | 1 314-200 NVL                     |
| LU-153 | Gasworks | Yellow Perch | Mononuc Infil    | 1    | 14-234  | NVL                            |      |      |      | 0-01 | NVL                 | 0-01 Notch Nuc-Rbc                |
| LU-154 | Gasworks | Yellow Perch | Mononuc Infil    | 2    | 14-482  | NVL                            |      |      |      | 0-01 | Focal Inflam        | 1 314-200 NVL                     |
| LU-155 | Gasworks | Yellow Perch | Non Uni Vacuol   | 1    | 14-483  | NVL                            |      |      |      | 0-01 | Trichodinids        | 1 314-34 NVL                      |
| LU-156 | Gasworks | Yellow Perch | Mononuc Infil    | 1    | 14-234  | NVL                            |      |      |      | 0-01 | Focal Inflam        | 1 314-200 Reticulocytes Aniso-Rbc |
| LU-77  | Gasworks | Sm Bass      | Granulomas       | 3    | 73-219  | NVL                            |      |      |      | 0-01 | NVL                 | 0-01 NVL                          |
| LU-87  | Gasworks | Sm Bass      | Pigmented Macro  | 2    | ?       |                                |      |      |      |      |                     |                                   |
|        |          |              | Non Uni Vacuol   | 2    | 14-483  | NVL                            |      |      |      | 0-01 | Focal Inflam        | 1 314-200 Leukocytosis            |
|        |          |              | Vacuolation      | 3    | 14-482  | NVL                            |      |      |      |      |                     |                                   |
|        |          |              | Granulomas       | 3    | 73-219  |                                |      |      |      |      |                     |                                   |
|        |          |              | Pigment Macro    | 2    | ?       |                                |      |      |      |      |                     |                                   |
|        |          |              | Ser Helminth     | 1    | 12-111  |                                |      |      |      |      |                     |                                   |
|        |          |              | Infamination     | 3    | 14-200  | NVL                            |      |      |      |      |                     |                                   |
|        |          |              | NVL              |      |         |                                |      |      |      |      |                     |                                   |
| LU-90  | Gasworks | Lm Bass      | Granulomas       | 2    | 73-219  | Vacuol Epithel                 |      |      |      | 0-01 | Aneurysms           | 1 314-907 Leukocytosis            |
| LU-91  | Gasworks | Lm Bass      | Paren Helminth   | 1    | 14-111  |                                |      |      |      |      |                     |                                   |
|        |          |              | Non Uni Vacuol   | 1    | 14-483  |                                |      |      |      |      |                     |                                   |
|        |          |              | Granulomas       | 2    | 73-219  | NVL                            |      |      |      | 0-01 | Focal Inflam        | 1 314-200 Accen Nuc-Rbc           |
|        |          |              | Non Uni Vacuol   | 3    | 14-483  |                                |      |      |      |      |                     |                                   |
|        |          |              | Focal Inflam     | 3    | 14-200  | NVL                            |      |      |      | 0-01 | NVL                 | 0-01 Crenated-Rbc                 |
|        |          |              | Granulomas       | 3    | 73-219  |                                |      |      |      |      |                     |                                   |
|        |          |              | Intes Adhesion   | 3    | 12-264  |                                |      |      |      |      |                     |                                   |
|        |          |              | Vacuolation      | 2    | 14-482  |                                |      |      |      |      |                     |                                   |
|        |          |              | Non Uni Vacuol   | 2    | 14-483  |                                |      |      |      |      |                     |                                   |
|        |          |              | Granulomas       | 2    | 73-219  | NVL                            |      |      |      | 0-01 | NVL                 | 0-01 Poikilo-Rbc Accen Nuc-Rbc    |
| LU-67  | Gasworks | Pumpkinseed  | Focal Pigment    | 2    | ?       | NVL                            |      |      |      | 0-01 | NVL                 | 0-01 Aniso-Rbc Lobul Nuc-Rbc      |
| LU-98  | Gasworks | Pumpkinseed  | Mononuc Infil    | 1    | 14-234  | Encys Parasite Inter Nephritis |      |      |      | 1    | 73-111 Focal Inflam | 1 314-200 NVL                     |
| LU-103 | Gasworks | Pumpkinseed  | NVL              |      | 0-01    | NVL                            |      |      |      | 0-01 | Monogenetic Trem    | 1 314-100 Pyk/Karyo-Mac Ghost Rbc |
| LU-105 | Gasworks | Pumpkinseed  | Non Uni Vacuol   | 2    | 14-483  | NVL                            |      |      |      | 0-01 | Aneurysms           | 2 314-907 Notch Nuc-Rbc           |
|        |          |              | Increase Mmc     | 2    | 103-726 |                                |      |      |      |      |                     |                                   |
|        |          |              | Mononuc Infil    | 1    | 14-234  |                                |      |      |      |      |                     |                                   |
|        |          |              | Basophil Cluster | ?    | 14-127  |                                |      |      |      |      |                     |                                   |
|        |          |              | Non Uni Vacuol   | 1    | 14-483  | NVL                            |      |      |      | 0-01 | Trichodinids        | 1 314-34 NVL                      |
|        |          |              | Pumpkinseed      | 1    | 14-308  | NVL                            |      |      |      | 0-01 | Focal Inflam        | 1 314-200 NVL                     |
|        |          |              | Pumpkinseed      | 1    | 14-234  | NVL                            |      |      |      | 0-01 | Stalked Ciliates    | 1 314-33 NVL                      |

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| NO.    | STATION  | SPECIES     | LIVER*         | SEV. | CODE*   | KIDNEY       | SEV. | CODE   | GILL             | SEV. | CODE          | BLOOD             |
|--------|----------|-------------|----------------|------|---------|--------------|------|--------|------------------|------|---------------|-------------------|
| LU-157 | Gasworks | Pumpkinseed | Non Uni Vacuol | 1    | 14-483  | NVL          |      | 0-01   | Monogenetic Trem | 1    | 314-100       | Aniso-Rbc<br>0-01 |
|        |          |             | Mononuc Infil  | 1    | 14-284  | NVL          |      | 0-01   | Aneurysms        | 1    | 314-907       | Accen Nuc-Rbc     |
|        |          |             |                |      | 0-01    | NVL          |      | 0-01   | Monogenetic Trem | 1    | 314-100       | Lobul Nuc-Rbc     |
|        |          |             |                |      | 0-01    | NVL          |      | 0-01   | NVL              | 0-01 | Notch Nuc-Rbc |                   |
| LU-159 | Gasworks | Pumpkinseed | Mononuc Infil  | 1    | 14-294  | NVL          |      | 0-01   | Aneurysms        | 1    | 314-907       | Accen Nuc-Rbc     |
| LU-160 | Gasworks | Pumpkinseed | NVL            | 1    | 0-01    | NVL          |      | 0-01   | Monogenetic Trem | 1    | 314-100       | Lobul Nuc-Rbc     |
| LU-161 | Gasworks | Pumpkinseed | Mononuc Infil  | 1    | 14-294  | NVL          |      | 0-01   | NVL              | 0-01 | Notch Nuc-Rbc |                   |
| LU-162 | Gasworks | Pumpkinseed | Paren Helminth | 1    | 14-111  |              |      | 0-01   | NVL              | 0-01 | Leucopenia    |                   |
|        |          |             | Granuloma      | 2    | 73-219  | NVL          |      |        |                  |      |               |                   |
|        |          |             | Mononuc Infil  | 2    | 14-294  |              |      | 0-01   | NVL              |      |               |                   |
|        |          |             | Ser Helminth   | 1    | 12-111  |              |      |        |                  |      |               |                   |
|        |          |             | Mononuc Infil  | 1    | 14-284  | Focal Inflam | 2    | 73-200 | NVL              | 0-01 | NVL           |                   |
|        |          |             | NVL            |      | 0-01    | NVL          |      | 0-01   | NVL              | 0-01 | Lobul Nuc-Rbc |                   |
| LU-163 | Gasworks | Pumpkinseed | Degen Parasite | 1    | 14-111  | NVL          |      | 0-01   | NVL              | 0-01 | NVL           |                   |
| LU-164 | Gasworks | Pumpkinseed | Paren Helminth | 1    | 14-111  |              |      |        |                  |      |               |                   |
| LU-165 | Gasworks | Pumpkinseed | Mononuc Infil  | 1    | 14-294  | NVL          |      | 0-01   | Monogenetic Trem | 1    | 314-100       | NVL               |
| LU-166 | Gasworks | Pumpkinseed | Mononuc Infil  | 1    | 14-284  | NVL          |      | 0-01   | Monogenetic Trem | 1    | 314-100       | Leucopenia        |
| LU-167 | Gasworks | Pumpkinseed | Mononuc Infil  | 1    | 14-294  | NVL          |      | 0-01   | Monogenetic Trem | 1    | 314-100       | Leucopenia        |
| LU-168 | Gasworks | Pumpkinseed | Mononuc Infil  | 1    | 14-294  | NVL          |      | 0-01   | Monogenetic Trem | 1    | 314-100       | NVL               |
| LU-169 | Gasworks | Pumpkinseed | Focal Necrosis | 1    | 14-308  | NVL          |      | 0-01   | Aneurysms        | 1    | 314-907       | NVL               |
| LU-170 | Gasworks | Pumpkinseed | Mononuc Infil  | 1    | 14-294  | NVL          |      | 0-01   | Monogenetic Trem | 1    | 314-100       | Leucopenia        |
| LU-171 | Gasworks | Pumpkinseed | Mononuc Infil  | 1    | 14-294  | Focal Inflam | 1    | 73-200 | NVL              | 0-01 | NVL           |                   |
| LU-7   | Gasworks | Sculpin     | NVL            | 1    | 0-01    | NVL          |      | 0-01   | Aneurysms        | 1    | 314-907       | NVL               |
| LU-112 | Gasworks | Sculpin     | Nuc Pleo       | 2    | 14-406  | NVL          |      | 0-01   | Focal Inflam     | 1    | 314-200       | NVL               |
| LU-113 | Gasworks | Sculpin     | Non Uni Vacuol | 2    | 14-483  |              |      | 0-01   | Stalked Ciliates | 1    | 314-33        | Accen Nuc-Rbc     |
|        |          |             | Focal Necrosis | 1    | 14-308  | NVL          |      |        |                  |      |               |                   |
|        |          |             | Nuc Pleo       | 2    | 14-406  | NVL          |      |        |                  |      |               |                   |
|        |          |             | Non Uni Vacuol | 1    | 14-483  |              |      |        |                  |      |               |                   |
|        |          |             | Mononuc Infil  | 1    | 14-234  |              |      |        |                  |      |               |                   |
|        |          |             | Increase Mmc   | 1    | 103-726 |              |      |        |                  |      |               |                   |
|        |          |             | Nuc Pleo       | 2    | 14-406  | NVL          |      | 0-01   | Aneurysms        | 1    | 314-907       | Accen Nuc-Rbc     |
|        |          |             | Non Uni Vacuol | 1    | 14-483  |              |      | 0-01   | Protozoa         | 1    | 314-74        |                   |
| LU-114 | Gasworks | Sculpin     | Congestion     | 2    | 126-950 | NVL          |      | 0-01   | NVL              | 0-01 | NVL           |                   |
| LU-119 | Gasworks | Bullhead    | Vacuolation    | 2    | 14-482  | NVL          |      | 0-01   | NVL              | 0-01 | Leucopenia    |                   |
| LU-174 | Gasworks | Bullhead    | Congestion     | 1    | 126-950 |              |      |        |                  |      |               |                   |
| LU-74  | Gasworks | Trout       | Not Examined   | N/A  | 0-0     | Not Examined |      |        |                  |      |               |                   |
| LU-79  | Gasworks | Trout       | Not Examined   | N/A  | 0-0     | Not Examined |      |        |                  |      |               |                   |
| LU-85  | Gasworks | Trout       | Not Examined   | N/A  | 0-0     | Not Examined |      |        |                  |      |               |                   |
| LU-99  | Gasworks | Trout       | Not Examined   | N/A  | 0-0     | Not Examined |      |        |                  |      |               |                   |
| LU-100 | Gasworks | Trout       | Not Examined   | N/A  | 0-0     | Not Examined |      |        |                  |      |               |                   |
| LU-75  | Gasworks | Sucker      | Not Examined   | N/A  | 0-0     | Not Examined |      |        |                  |      |               |                   |
| LU-76  | Gasworks | Sucker      | Not Examined   | N/A  | 0-0     | Not Examined |      |        |                  |      |               |                   |
| LU-89  | Gasworks | Sucker      | Not Examined   | N/A  | 0-0     | Not Examined |      |        |                  |      |               |                   |

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| NO.    | STATION   | SPECIES       | LIVER*            | SEV. | CODE*   | KIDNEY           | SEV. | CODE   | GILL                | SEV. | CODE            | BLOOD           |
|--------|-----------|---------------|-------------------|------|---------|------------------|------|--------|---------------------|------|-----------------|-----------------|
| LU-82  | Gasworks  | Chub          | Not Examined      | N/A  | 0-0     | Not Examined     | N/A  | 0-0    | Not Examined        | N/A  | 0-0             | Not Examined    |
| LU-86  | Gasworks  | Chub          | Not Examined      | N/A  | 0-0     | Not Examined     | N/A  | 0-0    | Not Examined        | N/A  | 0-0             | Not Examined    |
| LU-93  | Gasworks  | Bluegill      | Not Examined      | N/A  | 0-0     | Not Examined     | N/A  | 0-0    | Not Examined        | N/A  | 0-0             | Not Examined    |
| LU-158 | Gasworks  | Bluegill      | Not Examined      | N/A  | 0-0     | Not Examined     | N/A  | 0-0    | Not Examined        | N/A  | 0-0             | Not Examined    |
| LU-172 | Gasworks  | Crappie       | Not Examined      | N/A  | 0-0     | Not Examined     | N/A  | 0-0    | Not Examined        | N/A  | 0-0             | Not Examined    |
| LU-173 | Gasworks  | Crappie       | Not Examined      | N/A  | 0-0     | Not Examined     | N/A  | 0-0    | Not Examined        | N/A  | 0-0             | Not Examined    |
| LU-78  | Gasworks  | Squawfish     | Not Examined      | N/A  | 0-0     | Not Examined     | N/A  | 0-0    | Not Examined        | N/A  | 0-0             | Not Examined    |
| LU-111 | Gasworks  | Starry Floun. | Not Examined      | N/A  | 0-0     | Not Examined     | N/A  | 0-0    | Not Examined        | N/A  | 0-0             | Not Examined    |
| LU-1   | Navy Cove | Pumpkinseed   | Foc Vasc Conges   | 1    | 126-950 | NVL              |      | 0-01   | Mult. Aneurysms     | 1    | 314-907         | NVL             |
| LU-2   | Navy Cove | Pumpkinseed   | Focal Necrosis    | 1    | 14-308  | NVL              |      | 0-01   | NVL                 | 0-01 | NVL             |                 |
| LU-3   | Navy Cove | Pumpkinseed   | NVL               |      | 0-01    | NVL              |      | 0-01   | Interlam. Parasites | 1    | 314-185         | NVL             |
| LU-4   | Navy Cove | Pumpkinseed   | Fluid Filled Cyst | 2    | 14-902  | Granuloma        | 1    | 73-219 | NVL                 | 0-01 | Leukocytosis    |                 |
| LU-185 | Navy Cove | Pumpkinseed   | Mononuc Infil     | 1    | 14-234  | NVL              |      | 0-01   | NVL                 | 0-01 | Leucopenia      |                 |
| LU-186 | Navy Cove | Pumpkinseed   | Mononuc Infil     | 1    | 14-234  | Foc Inflam       | 1    | 73-200 | NVL                 | 0-01 | Notch Nuc-Rbc   |                 |
| LU-187 | Navy Cove | Pumpkinseed   | Mononuc Infil     | 1    | 14-234  | NVL              |      | 0-01   | Focal Inflam        | 2    | 314-200         | NVL             |
| LU-188 | Navy Cove | Pumpkinseed   | Increase Mmc      | 1    | 103-726 | NVL              |      | 0-01   | Monogenetic Trem    | 1    | 314-100         | Notch Nuc-Rbc   |
| LU-68  | Navy Cove | Pumpkinseed   | NVL               |      | 0-01    | Focal Necrosis   | 1    | 73-308 | Protozoan           | 1    | 314-74          | NVL             |
| LU-41  | Navy Cove | Stickleback   | Not On Slide      | N/A  | 0-0     | Tub Vacuol       | 2    | 20-482 | Trichodinids        | 1    | 314-34          | Bacteremia      |
| LU-42  | Navy Cove | Stickleback   | Non Uni Vacuol    | 1    | 14-483  | Foc Nec          | 1    | 73-308 | Aneurysms           | 1    | 314-907         | Aniso-Rbc       |
| LU-43  | Navy Cove | Stickleback   | Vacuolation       | 3    | 14-482  |                  |      |        |                     | 0-01 | Condens Chrom   |                 |
|        |           |               | Necrosis-Cystic   | 1    | 14-308  | Not On Slide     | N/A  | 0-0    | Encysted Helminth   | 1    | 314-111         | Reticulocytes   |
| LU-44  | Navy Cove | Stickleback   | Focal Necrosis    | 1    | 14-308  | NVL              |      | 0-01   | Monogenetic Trem    | 1    | 314-100         |                 |
| LU-45  | Navy Cove | Stickleback   | Coccidia          | 2    | 14-58   |                  |      | 0-01   | NVL                 | 0-01 | Condens Nuc Rbc |                 |
|        |           |               | Vcuolation        | 3    | 14-482  | NVL              |      | 0-01   | NVL                 | 0-01 | Accen Nuc-Rbc   |                 |
| LU-46  | Navy Cove | Stickleback   | Focal Inflam      | 1    | 14-200  |                  |      |        |                     | 0-01 | Rosettes        |                 |
|        |           |               | Non Uni Vacuol    | 1    | 14-483  | NVL              |      |        |                     |      |                 |                 |
|        |           |               | Ser Helminths     | 2    | 14-483  | NVL              |      |        |                     |      |                 |                 |
|        |           |               | Focal Necrosis    | 2    | 14-308  |                  |      |        |                     |      |                 |                 |
|        |           |               | Spongiosis        | 1    | 14-720  |                  |      |        |                     |      |                 |                 |
|        |           |               | Granulomas        | 1    | 73-219  | NVL              |      | 0-01   | Trichodinids        | 1    | 314-34          | NVL             |
|        |           |               | Focal Necrosis    | 2    | 14-308  |                  |      |        |                     |      |                 |                 |
|        |           |               | Non Uni Vacuol    | 1    | 14-483  | NVL              |      | 0-01   | Aneurysms           | 2    | 314-907         | Bacteremia      |
|        |           |               |                   |      | 0-01    | NVL              |      | 0-01   | Trichodinids        | 1    | 314-34          | Condens Nuc-Rbc |
|        |           |               |                   |      | 0-01    | NVL              |      | 0-01   | Aneurysms           | 1    | 314-907         | Accen Nuc-Rbc   |
|        |           |               |                   |      | 0-01    | Trichodinids     |      | 0-01   | Foc Hyperplasia     | 1    | 314-34          | Bacteremia      |
|        |           |               |                   |      | 0-01    | Aneurysms        |      | 0-01   | Macro Necrosis      | 1    | 314-707         |                 |
|        |           |               |                   |      | 0-01    | Monogenetic Trem |      | 2      | 314-907             |      |                 |                 |
|        |           |               |                   |      | 2       | 14-902           |      | 2      | 314-100             | NVL  |                 |                 |

\* See Appendix 3 for histopathology terms and codes.

**Appendix 2 (con't). Catalog of all fish collected and examined.**

| NO.    | STATION   | SPECIES      | LIVER*                           | SEV. | CODE*        | KIDNEY      | SEV. | CODE             | GILL         | SEV. | CODE       | BLOOD          |
|--------|-----------|--------------|----------------------------------|------|--------------|-------------|------|------------------|--------------|------|------------|----------------|
| LU-52  | Navy Cove | Stickleback  | Focal Necrosis<br>Non Uni Vacuol | 2    | 14-308       |             |      |                  |              | 2    | 314-34     | NVL            |
|        |           |              | Vacuoation                       | 1    | 14-483       | NVL         |      |                  |              |      |            |                |
|        |           |              | Hemorrhage                       | 3    | 14-482       | NVL         |      |                  |              |      |            |                |
|        |           |              | Focal Necrosis                   | 1    | 133-959      |             |      |                  |              |      |            |                |
| LU-53  | Navy Cove | Stickleback  | Vacuoation                       | 3    | 14-308       | NVL         |      |                  |              |      |            |                |
|        |           |              | Focal Fibrosis                   | 1    | 14-261       |             |      |                  |              |      |            |                |
|        |           |              | Encap Gran                       | 1    | 73-219       |             |      |                  |              |      |            |                |
|        |           |              | Vacuoation                       | 3    | 14-482       | NVL         |      |                  |              |      |            |                |
|        |           |              | Spongiosis                       | 1    | 14-720       |             |      |                  |              |      |            |                |
|        |           |              | Granuloma                        | 1    | 73-219       |             |      |                  |              |      |            |                |
| LU-54  | Navy Cove | Stickleback  | Vacuoation                       | 3    | 14-482       | NVL         |      |                  |              |      |            |                |
|        |           |              | Non Uni Vacuol                   | 3    | 14-483       |             |      |                  |              |      |            |                |
|        |           |              | Focal Necrosis                   | 2    | 14-308       |             |      |                  |              |      |            |                |
|        |           |              | Ser Helminth                     | 1    | 12-111       |             |      |                  |              |      |            |                |
|        |           |              | Nuc Pleomor                      | 2    | 14-406       |             |      |                  |              |      |            |                |
|        |           |              | Granulomas                       | 3    | 73-219       |             |      |                  |              |      |            |                |
| LU-56  | Navy Cove | Yellow Perch | NVL                              | 0-01 | Not On Slide | N/A         | 0-0  | Trichodinids     |              | 1    | 314-34     | NVL            |
| LU-57  | Navy Cove | Yellow Perch | Focal Necrosis                   | 1    | 14-308       | NVL         | 0-01 | NVL              |              |      | 0-01       | NVL            |
| LU-58  | Navy Cove | Yellow Perch | Granuloma                        | 1    | 73-219       | NVL         | 0-01 | Monogenetic Trem |              | 1    | 314-100    | NVL            |
|        |           |              | Mononuc Infil                    | 1    | 14-234       |             |      |                  |              |      | 0-01       |                |
| LU-59  | Navy Cove | Yellow Perch | Clear Cell Focus?                | 1    | 14-308       |             | 0-01 |                  |              |      |            |                |
| LU-60  | Navy Cove | Yellow Perch | Focal Necrosis                   | 1    | 14-308       | NVL         | 0-01 | Aneurysms        |              | 3    | 314-907    | NVL            |
| LU-61  | Navy Cove | Yellow Perch | Focal Necrosis                   | 1    | 14-483       | NVL         | 1    | 300-356          |              | 2    | 314-907    | Conden Nuc-Rbc |
| LU-62  | Navy Cove | Yellow Perch | Non Uni Vacuol                   | 1    | 14-234       |             | 0-01 | Monogenetic Trem |              | 1    | 314-34     |                |
|        |           |              | Mononuc Infil                    | 1    | 14-483       | Calculus    | 0-01 | Aneurysms        |              | 1    | 314-74     | Lobul Nuc-Rbc  |
| LU-175 | Navy Cove | Yellow Perch | Non Uni Vacuol                   | 1    | 14-483       | NVL         | 0-01 | Trichodinids     |              | 1    | 314-100    | NVL            |
| LU-176 | Navy Cove | Yellow Perch | Non Uni Vacuol                   | 3    | 14-482       | NVL         | 1    | 20-482           | Protozoan    | 3    | 314-907    |                |
| LU-177 | Navy Cove | Yellow Perch | Vacuoation                       | 3    | 14-482       | Vac Tub Epi | 0-01 | Monogenetic Trem |              | 1    | 314-100    | NVL            |
|        |           |              |                                  | 1    | 14-234       |             | 0-01 | Aneurysms        |              | 0-01 | Leucopenia |                |
| LU-178 | Navy Cove | Yellow Perch | Vacuoation                       | 3    | 14-234       | NVL         | 0-01 | Monogenetic Trem |              | 0-01 | NVL        |                |
|        |           |              | Mononuc Infil                    | 1    | 14-483       |             |      |                  |              |      |            |                |
|        |           |              | Mononuc Infil                    | 2    | 12-200       | NVL         |      |                  |              |      |            |                |
| LU-179 | Navy Cove | Yellow Perch | Non Uni Vacuol                   | 3    | 14-482       |             | 0-01 |                  |              | 1    | 314-34     |                |
| LU-180 | Navy Cove | Yellow Perch | Serositis                        | 2    | 14-482       | NVL         | 1    | 20-482           | Trichodinids | 1    | 314-34     | Leucopenia     |
| LU-181 | Navy Cove | Yellow Perch | Vacuoation                       | 2    | 14-482       | NVL         | 1    | 20-482           | NVL          | 0-01 | NVL        |                |
|        |           |              | Vacuoation                       | 1    | 14-234       | Vac Tub Epi | 1    | 20-482           | Trichodinids |      |            |                |
| LU-182 | Navy Cove | Yellow Perch | Vacuoation                       | 2    | 14-482       | Vac Tub Epi |      |                  |              |      |            |                |
|        |           |              | Mononuc Infil                    | 1    | 14-483       |             |      |                  |              |      |            |                |
|        |           |              | Vacuoation                       | 3    | 14-482       | Vac Tub Epi |      |                  |              |      |            |                |
|        |           |              | Non Uni Vacuol                   | 3    | 14-482       |             |      |                  |              |      |            |                |
|        |           |              | Vacuoation                       | 3    | 73-219       | NVL         | 1    | 20-482           | NVL          |      |            |                |
|        |           |              | Vacuoation                       | 3    | 14-482       | Vac Tub Epi | 1    | 0-01             | Protozoa     | 1    | 314-74     | NVL            |
|        |           |              | Granulomas                       | 2    | 14-308       | NVL         | 1    | 0-01             | Protozoa     | 1    | 314-907    | Leucopenia     |
|        |           |              |                                  |      |              |             |      |                  |              |      |            | Aniso          |

\* See Appendix 3 for histopathology terms and codes.

**Appendix 2 (con't). Catalog of all fish collected and examined.**

| NO.    | STATION     | SPECIES      | LIVER*   | SEV.                         | CODE*  | KIDNEY | SEV.   | CODE      | GILL    | SEV.                 | CODE          | BLOOD |
|--------|-------------|--------------|--|------------------------------|--|--------|--|-----------|---------|----------------------|---------------|-------|
| LU-70  | Navy Cove   | Sculpin      | Vacuolation<br>Focal Necrosis<br>Mononuc Infil<br>Structure?<br>Fatty Infil<br>Mononuc Infil<br>Fibrosis | 2<br>N/A<br>1<br>1<br>2<br>2 | 14-234<br>?<br>14-305<br>14-234<br>14-261<br>14-406<br>? | 0-01   | Aneurysm   | 1         | 314-33  | Accen Nuc-Rbc        |               |       |
| LU-71  | Navy Cove   | Sculpin      | N/A  | 0-01                         | Stalked Protozoan  | 2      | 314-707  | Aniso-Rbc |         |                      |               |       |
| LU-72  | Navy Cove   | Sculpin      | Nuclear Pleo<br>Clusters Of Ducts<br>Vacuolation<br>Cluster Of Ducts                                     | 2<br>?<br>2<br>1             | 14-482<br>?<br>14-483<br>14-406                          | 0-01   | Lamellar Hyperpla<br>Lamellar Fusion<br>Aneurysms<br>Monogenetic Trem? | 1         | 314-907 | Senescent Rbc<br>NVL |               |       |
| LU-73  | Navy Cove   | Sculpin      | Non Uni Vacuol<br>Nuclear Pleo<br>Squawfish<br>Squawfish   | N/A<br>N/A<br>0-0<br>0-0     | NVL  | 0-01   | Aneurysms  | 1         | 314-74  | Reticulocytes        |               |       |
| LU-120 | Navy Cove   | Squawfish    | N/A  | N/A                          | Protozoan  | 2      | 314-33   | NVL       |         |                      |               |       |
| LU-121 | Navy Cove   | Squawfish    | N/A  | N/A                          | 0-0  | 0-0    | 0-0  | 0-0       | 0-0     | 0-0                  | Aniso-Rbc     |       |
| LU-122 | Navy Cove   | Squawfish    | Not Examined   | N/A                          | Stalked Ciliates   | N/A    | N/A  | N/A       | N/A     | N/A                  | 0-0           |       |
| LU-124 | Portage Bay | Yellow Perch | Not Examined   | N/A                          | Protozoan  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | Lobul Nuc-Rbc |       |
| LU-127 | Portage Bay | Yellow Perch | Not Examined   | N/A                          | 0-0  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | 0-0           |       |
| LU-128 | Portage Bay | Yellow Perch | Not Examined   | N/A                          | 0-0  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | 0-0           |       |
| LU-133 | Portage Bay | Yellow Perch | Not Examined   | N/A                          | 0-0  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | 0-0           |       |
| LU-125 | Portage Bay | Pumpkinsseed | Not Examined   | N/A                          | 0-0  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | 0-0           |       |
| LU-126 | Portage Bay | Pumpkinsseed | Not Examined   | N/A                          | 0-0  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | 0-0           |       |
| LU-130 | Portage Bay | Pumpkinsseed | Not Examined   | N/A                          | 0-0  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | 0-0           |       |
| LU-132 | Portage Bay | Pumpkinsseed | Not Examined   | N/A                          | 0-0  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | 0-0           |       |
| LU-129 | Portage Bay | Lm Bass      | Not Examined   | N/A                          | 0-0  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | 0-0           |       |
| LU-134 | Portage Bay | Lm Bass      | Not Examined   | N/A                          | 0-0  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | 0-0           |       |
| LU-131 | Portage Bay | Crappie      | Not Examined   | N/A                          | 0-0  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | 0-0           |       |
| LU-123 | Portage Bay | Sucker       | Not Examined   | N/A                          | 0-0  | N/A    | 0-0  | 0-0       | 0-0     | 0-0                  | 0-0           |       |

\* See Appendix 3 for histopathology terms and codes.

## APPENDIX 3

# HISTOPATHOLOGY TERMS AND CODES

### ORGAN CODES

Liver (1)  
Kidney (2)  
Gills (3)

### LESION SEVERITY CODES

Mild (1)  
Moderate (2)  
Severe (3)

### HEPATOCELLULAR VACUOLATION CODES \*

No vacuolation (0)  
Minimal vacuolation (1)  
Moderate vacuolation (2)  
Extensive vacuolation (3)

### LESION CODES

#### GENERAL

NVL--no visible lesions (0-01)  
Not Examined--specimen not examined (0-0)  
Not On Slide--tissue not present on slide (0-0)  
Not Present--tissue not present on slide (0-0)

#### LIVER

Adhesion--fibrous attachment of liver serosa to adjacent organ, result of inflammation (12-264)  
Baso Hepatocytes--focus of increased basophilia (14-127)  
Baso MMCs--presence of basophilic cells in melanin macrophage center (103-127)  
Coccidia--coccidian parasites in liver tissue (14-58)  
Congestion--vascular hyperemia, probably not pathologic (126-950)  
Dark MMC--increased pigmentation in melanin macrophage centers (103-726) \*\*  
Dead Para--dead encapsulated parasite in tissue (14-111)  
Encap Para--encapsulated helminth parasite (14-111)  
Eosin Nod--nodular focus of increased eosinophilia (14-703)  
Fatty Infiltration--presence of adipose tissue in liver parenchyma (14-305)  
Fibrosis--proliferation of connective tissue in liver parenchyma (14-261)  
Foc Nec--focal necrosis in hepatocytes (14-308)  
Focal Inflam--spherical, active inflammatory focus (14-200)  
Granuloma (Granulomas)--a chronic inflammatory lesion (or lesions) generally associated with parasitism (73-219)  
Helm Gran--granuloma formed around helminth parasite (73-219)  
Hemorrhage--rupture of small vessels or sinusoids (133-959)  
MMC Dark--increased pigmentation in melanin macrophage centers (103-726) \*\*

MMCs--increased pigmentation in melanin macrophage centers (103-726) \*\*  
Mitotic Figure--increased mitotic activity in hepatocytes (14-529)  
Mono Infil--mononuclear cell infiltration; irregularly shaped aggregates or fingers of mononuclear cells (a type of inflammatory change) (14-234)  
Necrosis--focal necrosis in hepatocytes (14-308)  
Non Uni Vac--non uniform vacuolation of hepatocytes (14-483)  
Nuc Pleo--nuclear pleomorphism in hepatocytes (14-406)  
Para Cyst--helminth parasite in cystic space (14-902)  
Paren Cyst--cyst formation in parenchyma of liver (14-902)  
Parenc Hel--encapsulated, parenchymal parasite (14-111)  
Ser Helmin--serosal helminth (12-116)  
Serositis--serosal inflammation (12-200)  
Spong Hep--spongiosis hepatis; cystic spaces in liver parenchyma (14-720)  
Sporozoa--sporozoan parasite in lumen of bile duct (72-58)  
Vacuolation--degree of hepatocellular lipid vacuolation (14-482)\*

## KIDNEY

Calculus--presence of uroliths within portion of nephron (300-356)  
Duc Inflam--inflammatory cells in ductular epithelium (351-200)  
Encap Para--encapsulated helminth parasite (73-111)  
Foc Necrosis--necrosis of interstitial tissue (73-308)  
Glomer Pig--presence of unidentified pigment in glomerulus (301-363)  
Granuloma (Granulomas)--a chronic inflammatory lesion (or lesions) generally associated with parasitism (73-219)  
Inflam--inflammatory focus in interstitial tissue (73-200)  
Necrosis--necrosis of interstitial tissue (73-308)  
Nephritis--inflammatory focus in interstitial tissue (73-200)  
Periduc Infl--inflammation surrounding collecting duct (73-200)  
Sporo Duct--sporozoan parasites in lumen of collecting duct (351-58)  
Sporozoa--sporozoan parasites in lumen of collecting duct (351-58)  
Tub Inflamm--inflammatory cells in epithelium of tubule (20-200)  
Vac Tub Epi--vacuolation of tubular epithelium (20-482)

## GILLS

Aneurysm (Aneurysms)--aneurysms; localized dilation of capillary lumen (314-907)  
Encap Para--encapsulated parasite (313-111)  
Foc Hyperpl--focal hyperplasia of lamellar epithelium (314-707)  
Focal Inflam--focal inflammation of lamellae (314-200)  
Helminth--presence of unidentified helminth parasite on gill lamellae (314-111)  
Hyperplas--focal hyperplasia of lamellar epithelium (314-707)  
Monogenetic Trem--presence of monogenetic trematode on gill lamellae (314-100)  
Parasite--presence of unidentified parasite on gill lamellae (314-185)  
Protozoan--presence of unidentified protozoan parasite on gill lamellae (314-74)  
Stalked Cil--presence of stalked ciliates on gill lamellae (314-33)  
Trichodinids--presence of Trichodina sp. between gill lamellae (314-34)

## BLOOD

Accen Nuc RBC/Reticulocyte--acentric nucleus in mature or immature red blood cell

Aniso-RBC/Reticulocyte--anisocytosis of mature or immature red blood cells; cell size different (usually larger) from normal  
Bacteremia--presence of bacteria in blood stream  
Crenated RBC--cell membrane of red blood cell highly folded  
Ghost RBC--remnants of red blood cell outlines; dead cells  
Karyol-WBC--karyolysis of white blood cell nucleus  
Leucocytosis--increased number of white blood cells; often a sign of active infection or inflammation  
Leukopenia--decreased number of white blood cells; often a sequella of infection  
Lobed RBC Nuclei--abnormally shaped nucleus in red blood cell; lobed  
Notch Nuc RBC--abnormally shaped nucleus in red blood cell; notched  
Poikilo RBC--red blood cells of mixed sizes and shapes  
Pyknotic RBC--nuclear chromatin in red blood cell condensed  
Regen Anemia--regenerative anemia  
Reticulocytes--presence of immature red blood cells  
Rosette-RBC--Clusters of white blood cells around red blood cell  
Seg Nuc RBC--abnormally shaped nucleus in red blood cell; segmented  
Vac Macro--activated (vacuolated) macrophages

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- \* Hepatocellular vacuolation is not a pathological lesion. Rather it reflects changes in physiological state.
- \*\* Increased pigmentation of melanin macrophage centers is a condition that frequently accompanies chronic exposure to contaminants, but that may also be encountered in animals of advanced age. The verbal descriptors used in the data set are synonyms that were used interchangably to describe the condition that is coded 103-726.